ZooKeys 793: 63–96 (2018)
doi: 10.3897/zookeys.793.28050
http://zookeys.pensoft.net

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A synopsis of Estonian myriapod fauna (Myriapoda: Chilopoda, Diplopoda, Symphyla and Pauropoda)

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Academic editor: *Nesrine Akkari* | Received 28 June 2018 | Accepted 17 September 2018 | Published 29 October 2018

http://zoobank.org/0D7B2412-5585-4AEA-81D4-1854A4415128

Citation: Sammet K, Ivask M, Kurina O (2018) A synopsis of Estonian myriapod fauna (Myriapoda: Chilopoda, Diplopoda, Symphyla and Pauropoda). ZooKeys 793: 63–96. https://doi.org/10.3897/zookeys.793.28050

Abstract

The data on Estonian Myriapoda are scattered in various publications and there has been no overview of the fauna up to the present. A critical summary of the previous information on Estonian Myriapoda is given, supplemented by new records and distribution maps. Altogether, 5784 specimens from 276 collecting sites were studied. To the hitherto recorded 14 centipede species are added *Lithobius melanops*, *L. microps*, *Geophilus carpophagus*, *G. flavus*, *Strigamia transsilvanica* and *Stenotaenia linearis*, a probably introduced species. Of the 27 published Estonian millipede species, the data on two species proved erroneous, and two new species were recorded (*Craspedosoma raulinsii* and *Cylindroiulus britannicus*). Two previously recorded millipede species – *Brachyiulus pusillus* and *Mastigophorophyllon saxonicum* – were not found in the recent samples, the latter may have become more rare or extinct. Pauropoda and Symphyla lack previous reliable records. Combined with published data, the number of myriapod species known from Estonia is now set at 52. Some changes in species distribution and frequencies were detected comparing the published data with new records. Some data about habitat preferences of the more common species are also given. The majority of species have a western Palaearctic distribution, while six species are at the northern limit of their ranges.

Keywords

check list, Chilopoda, Diplopoda, distribution, Estonia, Myriapoda, Pauropoda, soil invertebrates, Symphyla

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Introduction

The research of Estonian Myriapoda has been quite unsystematic and sporadic. Very little has been published in English thus much of the information may be currently unavailable to the wider myriapodological community (e.g., Zapparoli 2003, Tuf et al. 2015). The first scant records of Myriapoda in Estonia date back to the second half of the XIX century. The first data are given by E. Haase (Haase 1886: 58), who mentions a "*Craspedosoma mutabile* v. *fasciatum* Latzel, 1884" specimen collected by A. E. Grube from Tartu. Subsequently, P. Schmidt reported the presence of *Pauropus Huxleyi* in the vicinity of Narva (Schmidt 1894) and O. Schubart published the data on two millipede species collected from Estonian bogs (Schubart 1924). W. Mierzeyewski collected in 1912 and 1926 some millipedes in the island Saaremaa, and in the years 1925 to 1929 W. Herold gathered a considerable millipede material from many places in Estonia. That material, containing 20 species, was also identified and published by O. Schubart (Schubart 1930), who repeated the data in his monograph on German Diplopoda (Schubart 1934). Part of the Herold material is currently preserved in the collection of Museum für Naturkunde, Berlin. In the 1930's, some ecological studies mention millipedes identified to genus level (e.g., Nõmmik 1939) and some species were listed in studies on plant pests (e.g., Zolk 1923, Kaarep et al. 1949). E. Palmén published one new record of Estonian diplopods in his overview of the Finnish fauna (Palmén 1949).

An unpublished collection of myriapods from 1937, preserved currently in the entomological collection of Estonian University of Life Sciences, Tartu (IZBE, identified by the Swedish zoologist H. Lohmander), has probably served as a basis to the list of ten centipede species in H. Riikoja's account of Estonian invertebrates (Riikoja 1955; referred to as pers. comm. with J. Vilbaste).

We owe thanks for much of what is known about Estonian Myriapoda to the works of the Estonian entomologist Juhan Vilbaste (1924–1985). His "Keys to Estonian Millipedes" lists 21 species as proven to occur in Estonia at that time (Vilbaste 1953). In addition, he published on Myriapoda in several local faunistic surveys, adding one centipede and five millipede species records and some ecological observations (Vilbaste 1970, Vilbaste 1979, Vilbaste et al. 1985, Vilbaste and Vilbaste 1993). Unfortunately, only two specimens of Vilbaste have subsisted (in the IZBE collection). The data provided by Schubart (1930) and Vilbaste (1953) have been reproduced by various subsequent authors (e.g., Lang 1954, Stojałowska 1961, Lokshina 1969). Thus, 14 centipede species and 27 millipede species were recorded from Estonia prior to the current study.

Material and methods

As complete as possible, bibliography of historical records of myriapods in Estonia was compiled, reviewing all the available faunistic studies and other records. The main Estonian zoological collections were searched for myriapod material (Estonian Museum of Natural History, Tallinn; Tartu University Museum of Natural history and the

private insect collection of Allan Selin, Maardu). Some collections abroad known to house Estonian material were contacted for further information (Finnish Museum of Natural History and Zoologische Staatssammlung München, Germany).

New material was collected using: (1) pitfall traps, (2) Tullgren funnel and Kempson apparatus, (3) sifting moss, leaf litter and detritus with a standard entomological sieve, (4) manual searching in suitable habitats and daytime retreats, and (5) as by-catch of non-target species with window pane traps (attached to tree trunks) and Malaise traps (for particular description of the trapping projects, see Sammet et al. 2016 and Tomasson et al. 2014, respectively).

The material was collected from 276 localities covering all parts of Estonia (see Table 1 and Figure 1 for details). The distribution of Estonian species (Figures 2–5) is presented in 50×50 km UTM grid, also used in the „Atlas of European Millipedes" (Kime and Enghoff 2011, 2017) (compiled using Adobe Photoshop CS5 Extended). The relative abundances in different habitats of species with at least 25 findings were presented as diagrams (Figures 6–8). The habitats studied repeatedly with different methods were grouped into 14 types:

1. Coastal meadows and alvars;
2. Broad-leaved (nemoral) forests (dominated by *Quercus robur*, *Tilia cordata*, *Acer platanoides* and herbs in the understory);
3. Boreo-nemoral deciduous forests (dominated by *Alnus incana* or *Salix* species);
4. Dry heathland forests (dominated by *Pinus sylvestris*, with *Cladonia* sp. or *Calluna vulgaris* in understory);
5. Drier boreo-nemoral mixed forests (dominated by *Pinus sylvestris* with *Sorbus* and *Acer* and *Vaccinium myrtillus* in understory);
6. Mesophilic boreal forests (dominated by *Picea abies*, *Oxalis acetosella* in understory);
7. Hillock forests (dominated by *Corylus avellana*, herbs in the understory);
8. Carrs and paludifying forests (dominated by *Picea abies*, *Betula pendula* and *Pinus sylvestris*);
9. Bogs;
10. Fens and waterlogged meadows;
11. Inland mesophilic grasslands;
12. Rural gardens;
13. Urban parks and graveyards;
14. Arable fields.

The barplot diagrams were produced by dividing the number of findings in a habitat type by the proportion of sampling effort in that particular habitat (i.e. the number of "sampling events" consisting of one trapping period or one hand collecting trip with subsequent Tullgren extraction of soil and litter samples) (Figure 6). Other, more rare, habitats that were not studied with all the methods are not included. All studied material is preserved in 70% ethanol or a mix of ethanol and glycerol for Pauropoda.

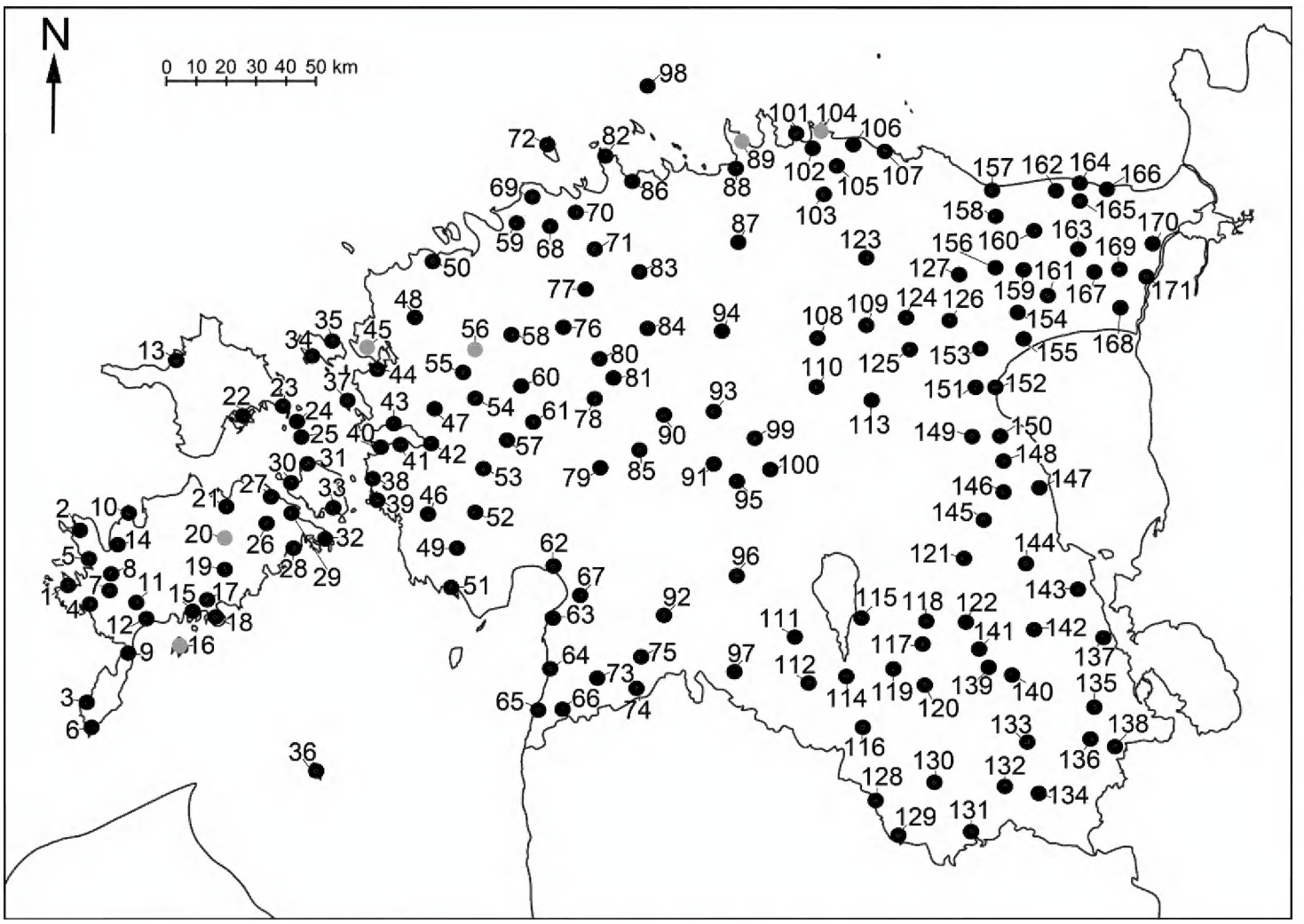

Figure 1. Collecting localities of Myriapoda in Estonia. Key: Dark circles = this study, light circles = literature data. For further details, see Table 1.

Some gonopods are preserved as microscope slides (using Euparal). The studied material is deposited in the entomological collection of Estonian University of Life Sciences (**IZBE**) and the soil biology collection of Tallinn University of Technology (**TTUSB**), both in Tartu, Estonia. Various keys for Central, Northern, and East, European myriapods were used for identification (Schubart 1934, Lokshina 1969, Zalesskaya 1978, Blower 1985, Andersson et al. 2005, Bonato et al. 2005, Barber 2009).

Results

All available material consisting of 1656 centipede, 4095 millipede, 29 symphylan, and six pauropod specimens were identified or re-identified and databased. The following list contains all the known published records of Estonian myriapods, followed by numbers of studied specimens and collecting localities. Full details for one finding from each locality are given in "Supplementary information". Only publications with original data are listed, subsequent ones citing these (e.g., Schubart 1934, Lang 1954, Stojałowska 1961, Lokshina 1969, Atlavinytė and Lokshina 1971, Blower 1985, Spuņģis 2010) are omitted. An asterisk (*) marks previously unpublished species. The full list of records with all details will be available through the Estonian eBiodiversity portal (http://elurikkus.ut.ee; Abarenkov et al. 2010) and Global Bi-

Table 1. Collecting localities of Estonian myriapods. The localities' numbers correspond to those on Figure 1. Localities within a range of less than 10 km are presented by one number, the different place names (sub-localities) under one number are designated consecutive letters (the coordinates apply only to the first of them).

No	Latitude, N	Longitude, E	Name
1	58.3300	21.9627	a Kuusnõmme, b Eeriksaare, c Atla
2	58.4467	21.9391	a Kõruse, b Undva, c Tagamõisa, d Neeme, e Tammese
3	57.9777	21.9971	Türju
4	58.2467	22.0311	Kipi
5	58.3909	22.0051	a Oju, b Vilsandi,
6	57.9095	22.0552	Sõrve peninsula
7	58.2833	22.1000	a Audaku, b Sutru, c Kivesselja, d Pätsumaa bog, e Pitkasoo, f Suurissoo hill, g Surnuaiamägi, h Nakimetsa, i Suurmägi, j Laasma, k Viidumägi, l Upsi
8	58.3163	22.0806	a Kanna, b Viidu
9	58.1234	22.1946	Lõu
10	58.5105	22.2330	Kugalepa
11	58.3188	22.3066	a Mõnnuste, b Paadla
12	58.2209	22.2752	Kaalupi
13	58.9414	22.4362	Paope
14	58.3986	22.1278	Viidumäe, Jürna liivad
15	58.2424	22.4246	Suurlaht
16	58.1453	22.0570	Abruka
17	58.3005	22.6459	a Ilpla, b Kudjape
18	58.2256	22.6885	Vanamõisa
19	58.3725	22.6697	a near Kaali lake, b Võrsna
20	58.4563	22.7076	Tika
21	58.5397	22.7307	Õeste
22	58.7962	22.7555	a Reigilaid, b Kassari
23	58.8289	22.9746	a Suur-Pihlakare, b Öakse, c Saarnaki, d Aruküla, e Heltermaa, f Sarve
24	58.7956	23.0063	a Saarnaki, b Hanikatsi, c Langekare
25	58.7421	23.1349	Ahelaid
26	58.4828	22.9800	a Koigi lake; b Koigi bog
27	58.5846	23.0246	Orinõmme
28	58.4394	23.0680	Asva
29	58.5506	23.1319	Orissaare
30	58.6114	23.0911	a Koguva, b Lepanina
31	58.6406	23.1588	a Paenase, b Nõmmküla, c Üügu, d Lõetsa
32	58.4568	23.2673	a Kahtla, b Kübassaare
33	58.5794	23.2709	a Mäla, b Võiküla
34	58.9697	23.2058	Vormsi: Kärret
35	59.0347	23.3047	Vormsi: Diby
36	57.8062	23.2396	Ruhnu
37	58.8377	23.3958	Liialaid
38	58.6421	23.5167	Hanila
39	58.5609	23.5522	a Puhtu, b Laelatu, c Pivarootsi
40	58.6918	23.5821	a Salevere Salumägi, b Saastna, c Metsküla
41	58.7440	23.6719	a Keemu, b Kirikuküla Tika, c Kirikuküla Allika, d Kirikuküla Ennu, e Viita, f Penijõe
42	58.7531	23.8465	a Kloostri, b Kelu, c Rõude, d Kasari, e Kirbla
43	58.8089	23.7011	Rannamõisa
44	58.9492	23.5681	a Haapsalu, b Linnamäe
45	59.2049	23.5988	Noarootsi
46	58.5336	23.8299	Paaderma
47	59.0356	23.6382	Ingiküla
48	59.0371	23.6609	Niibi
49	58.4319	24.0003	Tõhela
50	59.2594	23.8737	Vihterpalu
51	58.3144	23.9850	a Tõstamaa, b Suti
52	58.5380	24.0062	Nedrema
53	58.6455	24.1254	Kurese

No	Latitude, N	Longitude, E	Name
54	58.8075	24.0094	Patsu fen
55	58.9020	24.0284	a Marimetsa NR, b Kullamaa
56	58.9972	24.0562	Risti
57	58.7757	24.2498	Vana-Vigala
58	59.0723	24.2934	Turba bog
59	59.3315	24.3745	Tõmmiku
60	58.8958	24.3769	a Sõtke, b Valgu, c Raela
61	58.7805	24.5625	Inda
62	58.3884	24.5093	Pärnu
63	58.1369	24.5141	a Tolkuse bog, b Uulu,
64	58.0996	24.4737	a Pulgoja, b Pikla, c Häädemeeste
65	58.0067	24.4423	a Kabli b near Ikla
66	57.9947	24.5378	Laulaste NR
67	58.2709	24.6411	Laadi
68	59.3194	24.5581	a Saue, b Pääsküla
69	59.3816	24.4628	Vahi küla
70	59.3915	24.6434	Vana-Mustamäe
71	59.2661	24.6483	Kasemetsa-Kuresoo
72	59.5933	24.5025	Naissaar
73	58.0783	24.8338	Tali
74	58.0027	24.8769	Sookuninga NR
75	58.0711	24.8608	Kalita NR
76	58.9549	24.7641	a Raela, b Varbola
77	59.0725	24.8077	Hagudi
78	58.8879	24.6391	Loe
79	58.6328	24.7013	Lehu bog
80	58.9742	24.7021	Kuusiku; Keo
81	58.8983	24.7616	a Kõnnu, b Lellepere
82	59.5297	24.8577	Lubja
83	59.2377	24.9311	2km SE of Sõmeru
84	58.9459	25.1025	Loosalu
85	58.7080	24.8780	a Kõnnu bog, b Luuri bog
86	59.4630	24.9377	Maardu
87	59.2781	25.6212	Aegviidu
88	59.5084	25.5925	Uuri
89	59.5841	25.6263	Hara island
90	58.8165	25.1625	Käru
91	58.6396	25.3039	a Ramussaare, b Pikkmetsa, c Tõrvaaugu
92	58.2719	25.1798	Riimaru
93	58.8099	25.3394	Lokuta
94	59.0835	25.4052	a Mustla, b Mustla Pühajärv
95	58.6333	25.5500	a Võhma, b Koksvere
96	58.3593	25.5950	Viljandi
97	58.0818	25.5253	Viivre
98	59.6991	25.0211	Keri island
99	58.7259	25.6007	a Retla, b Kabala
100	58.6475	25.6717	a Arussaare, b Kirivere, c Järavere
101	59.6049	25.9229	Käsmu
102	59.5778	25.9556	Võsu
103	59.4481	26.0126	Viitna
104	59.4484	26.0118	Koljaku-Oandu NR
105	59.5166	25.9746	Palmse
106	59.5660	26.0880	a Oandu, b Vihula
107	59.5557	26.3533	Rutja; Varangu
108	58.9765	26.0454	Koeru
109	59.0232	26.2443	a Kamariku, b Rakke
110	58.8839	26.0433	Sopaalliku
111	58.1413	25.6803	Muti NR
112	58.0180	25.8794	Helme

No	Latitude, N	Longitude, E	Name
113	58.8457	26.2919	a Kärde hill, b Kaera, c Pedja
114	58.0063	26.0553	Soontaga NR
115	58.2388	26.1770	a Rannu, b 2 km SW of Rannu
116	57.9127	26.1883	Õru
117	58.1803	26.4205	Elva-Vitipalu NR
118	58.2386	26.4433	a Peedu, b Vapramäe
119	58.0399	26.2073	Prange
120	58.0533	26.4898	Otepää
121	58.3808	26.6222	a Rahinge, b Tiksoja, c Tähtvere bog, d Õssu, e Tartu Eerika, f Merimetsa, g Tartu Tähtvere, h Kõrveküla
122	58.2301	26.7010	Kambja
123	59.1857	26.1980	a Porkuni, b Lasila
124	59.0373	26.6758	between Venevere and Arukse
125	59.0115	26.4265	Karaski
126	58.9092	26.5046	a Pedjaääre, b Tudusoo NR
127	59.1527	26.8213	Suigu NR
128	57.6878	26.1854	Vaitka
129	57.6049	26.2749	Koiva wooded meadow, b Koivakonnu, c Taheva
130	57.7522	26.4926	a Karula Mähkli, b Küünimetsa
131	57.5727	26.6413	Mõisamõtsa NR
132	57.6938	26.8850	Saarlasõ küla
133	57.8386	27.0505	Võrusoo
134	57.7355	27.0627	Haanja NR
135	57.9422	27.4058	a Rebasemäe, b Ilumetsa
136	57.8433	27.4626	Piusa
137	58.1287	27.4990	Räpina
138	57.8168	27.5180	Obinitsa
139	58.0911	26.9050	Palojärv
140	58.0524	27.0286	Puuri
141	58.1514	26.8731	a Voorepalu, b Ihamaru NR
142	58.1777	27.1467	Mooste
143	58.2781	27.3210	Järvselja
144	58.3287	26.9892	Melliste
145	58.5170	26.9223	Konnamõisa
146	58.5633	26.8772	a Välgi NR, b Särgla, c Pataste
147	58.6032	27.1301	Alatskivi
148	58.6558	26.9469	a Pala, b Padakõrve NR
149	58.7296	26.8244	a Odivere, b Maarja-Magdaleena
150	58.7394	26.9452	Jõeääre
151	58.7430	26.8888	a Ruskavere. b Võtikvere NR
152	58.7841	26.9330	Nõmme
153	58.9636	26.8294	a Kõveriku, b Avinurme
154	59.0230	27.0591	Tudulinna
155	58.9656	27.0303	Lohusuu
156	59.1732	26.9438	Kaukvere
157	59.4443	26.9047	Aseri taga
158	59.3588	26.9238	Kiviõli
159	59.1644	27.0133	Muraka NR
160	59.3179	27.1235	Aidu
161	59.0894	27.1550	Muraka NR
162	59.3858	27.2218	Kohtla-Järve
163	59.2289	27.3247	Mäetaguse NR
164	59.4439	27.3350	a Valaste falls, b 5 km W of Toila
165	59.3948	27.3408	Kukruse
166	59.4302	27.3900	Toila
167	59.1523	27.3889	Jõuga
168	59.0711	27.6277	Agusalu LKA
169	59.0767	27.7033	Permisküla
170	59.2384	27.8377	Narva
171	59.1719	27.7961	a Poruni, b Gorodenka

odiversity Information Facility (http.//www.gbif.org). The nomenclature and synonymies follow the ChiloBase (Bonato et al. 2016), "Atlas of European millipedes" (Kime and Enghoff 2011, 2017) and McAlpine and Shear (2018) for centipedes and millipedes, respectively, and the "Catalogue of Myriapoda in the Nordic Countries" (Andersson et al. 2008, 2013) for Symphyla and Pauropoda. For each species, a brief overview of its distribution is given (with emphasis on North-Eastern Europe).

1. Chilopoda
1.1. Geophilomorpha
1.1.1. Geophilidae

******Geophilus carpophagus* **Leach, 1814**
Fig. 2(1)

Studied material. 2 specimens from 2 localities.

General distribution. Western Palaearctic species (Andersson et al. 2005), present also in southern Sweden and south-western Finland (Andersson et al. 2008), Latvia (Bonato et al. 2005) and Lithuania (Tuf et al. 2015).

Comments. The species is rare in Estonia.

Geophilus electricus **(Linnaeus, 1758)**
Fig. 2(2)

Literature sources. Volkova 2016: 504.

Studied material. 5 specimens from 4 localities.

Distribution. Western Palaearctic species introduced also to North America (Andersson et al. 2005), present also in southern Sweden and south-western Finland (Andersson et al. 2008), Latvia (Bonato et al. 2005) and Lithuania (Tuf et al. 2015).

Comments. The species is rare in Estonia.

******Geophilus flavus* **(De Geer, 1778)**
Figs 2(3), 6

Literature sources. Ivask et al. in press.

Studied material. 68 specimens from 24 localities.

General distribution. Western Palaearctic species introduced also to North America (Andersson et al. 2005), widespread in Scandinavia and Finland (Andersson et al. 2008), Latvia (Bonato et al. 2005) and Lithuania (Tuf et al. 2015).

Comments. A common species in different habitats, but absent in wet areas.

***Geophilus proximus* C.L. Koch, 1847**
Figs 2(4), 6

Literature sources. Riikoja 1955: 15, Ivask 2011: 2, Ivask et al. in press.

Studied material. 57 specimens from 26 localities.

General distribution. Central and North European species, (Andersson et al. 2005), widespread in Scandinavia and Finland (Andersson et al. 2008), Latvia (Bonato et al. 2005) and Lithuania (Tuf et al. 2015).

Comments. A common species in different habitats, but absent in wet areas.

***Geophilus truncorum* Bergsoe & Meinert, 1866**
Figs 2(5), 6

Literature sources. Vilbaste 1970: 174, Vilbaste et al. 1985: 152, Vilbaste and Vilbaste 1993: 319 [as: *Brachygeophilus truncorum* Mnr.], Ivask et al. in press.

Studied material. 66 specimens from 27 localities.

General distribution. Western Palaearctic species, present also in southern Sweden and south-western Finland (Andersson et al. 2008), Latvia (Bonato et al. 2005) and Lithuania (Tuf et al. 2015).

Comments. A common species in different habitats, especially in soil samples.

******Stenotaenia linearis* **(C.L.Koch, 1835)**
Fig. 2(7)

Studied material. 5 specimens from 1 locality.

General distribution. Western Palaearctic species, exclusively synanthropic in northern Europe, present also in Latvia (Bonato et al. 2005) and Finland (Andersson et al. 2008).

Comments. The species was recently shown to comprise several cryptic lineages (Wesener et al. 2015). It is probably an introduced species in Estonia (only found in the Tartu Botanical Garden in Estonia and present also only synanthropically in the neighbouring countries).

***Pachymerium ferrugineum* (C. L. Koch, 1835)**
Figs 2(6), 6

Literature sources. Riikoja 1955: 15, Vilbaste 1970: 174, Vilbaste et al. 1985: 152, Ivask et al. in press.

Studied material. 31 specimens from 14 localities.

General distribution. Holarctic species (Andersson et al. 2005), widespread in Sweden and Finland (Andersson et al. 2008), Latvia (Bonato et al. 2005) and Lithuania (Tuf et al. 2015).

Comments. The species is more common in coastal areas and rare elsewhere. It seems to favour dry habitats.

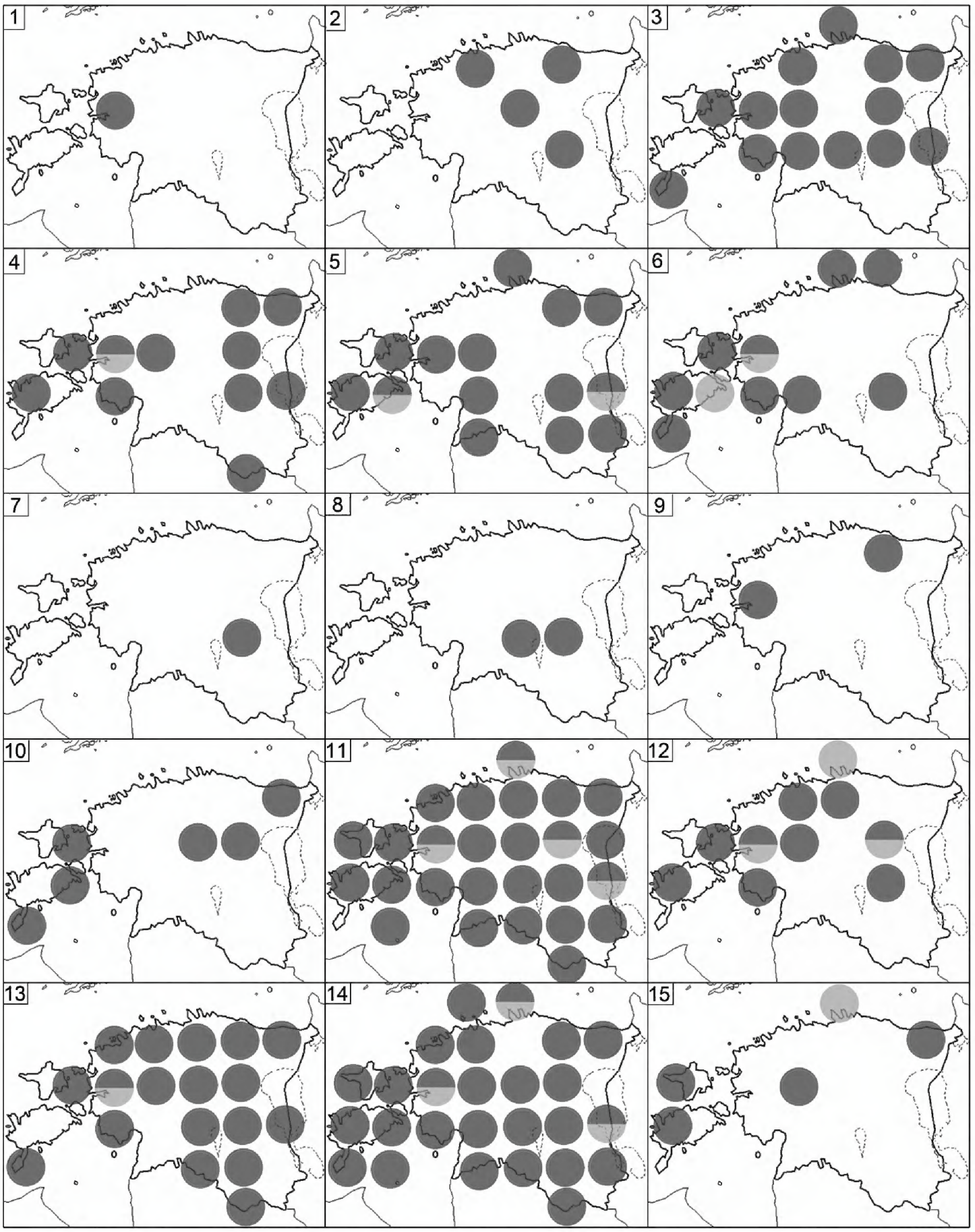

Figure 2. Distribution of Estonian Chilopoda. **1** *Geophilus carpophagus* **2** *G. electricus* **3** *G. flavus* **4** *G. proximus* **5** *G. truncorum* **6** *Pachymerium ferrugineum* **7** *Stenotaenia linearis* **8** *Strigamia transsilvanica* **9** *Lamyctes emarginatus* **10** *Lithobius borealis* **11** *L. curtipes* **12** *L. crassipes* **13** *L. erythrocephalus* **14** *L. forficatus* **15** *L. lucifugus*. Key: Dark circles = original data, light circles = literature data, divided circles = original and literature data.

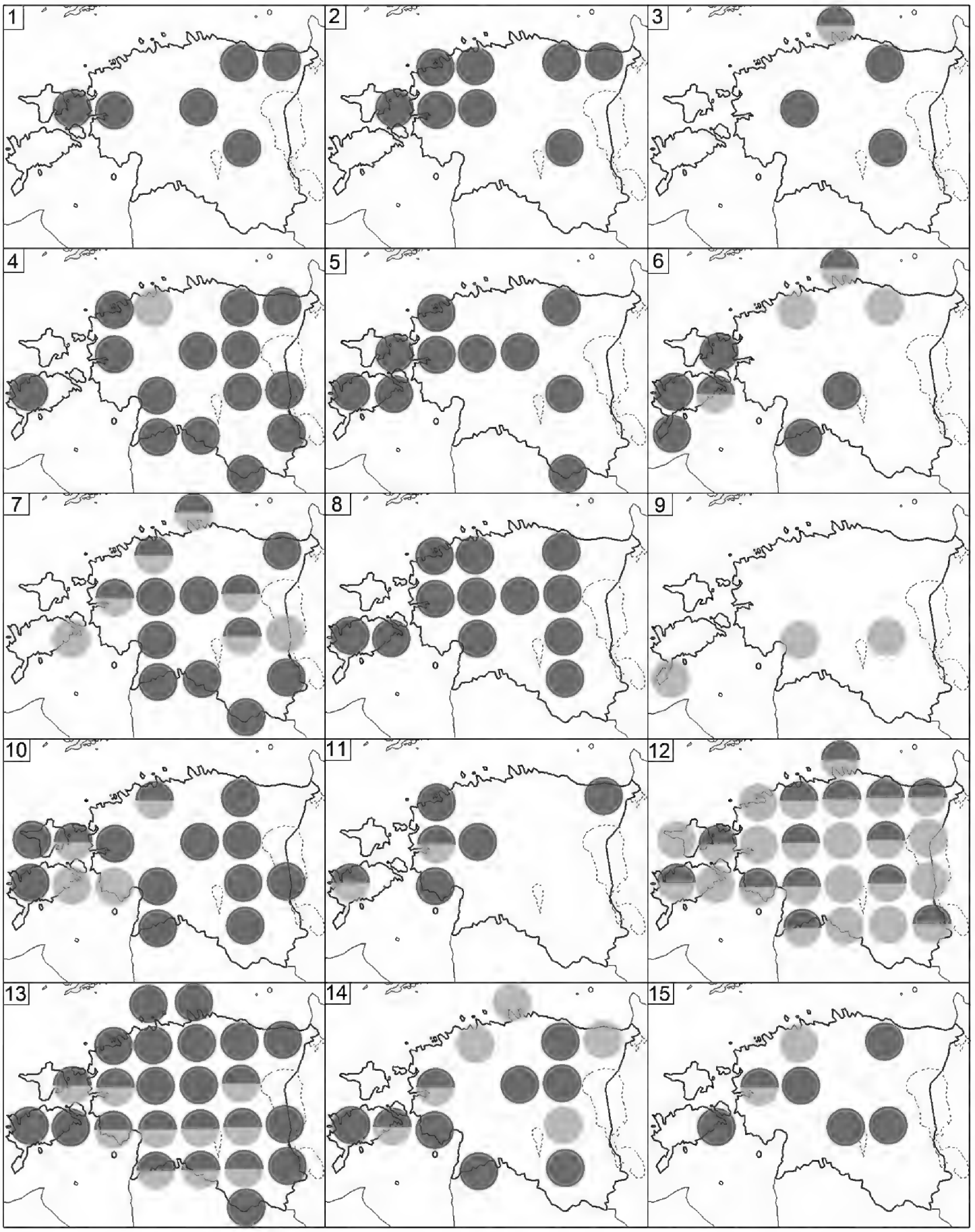

Figure 3. Distribution of Estonian Chilopoda (**1–5**) and Diplopoda (**6–15**). **1** *Lithobius melanops* **2** *L. microps* **3** *L. pelidnus* **4** *L. tenebrosus* **5** *Schendyla nemorensis* **6** *Polyxenus lagurus* **7** *Polyzonium germanicum* **8** *Craspedosoma raulinsii* **9** *Mastigophorophyllon saxonicum* **10** *Nemasoma varicorne* **11** *Brachydesmus superus* **12** *Polydesmus complanatus* **13** *P. denticulatus* **14** *P. inconstans* **15** *Blaniulus guttulatus*. For symbols see Fig. 2.

1.1.2 Linotaeniidae

***_Strigamia transsilvanica_ (Verhoeff, 1928)**
Fig. 2(8)

Studied material. 3 specimens from 2 localities.

General distribution. Mainly a Central European species but recently found also in Latvia (Bonato et al. 2005). The species has no published records from north-western Russia (Volkova 2016), but there is a specimen collected from Izborsk (Pskov region, 10 km of Estonian border) in the IZBE collection.

Comments. The species is rare in Estonia. Both findings are from human settlements.

1.1.3. Schendylidae

***Schendyla nemorensis* (C.L. Koch, 1837)**
Fig. 3(5)

Literature sources. Riikoja 1955: 15, Ivask et al. in press.

Studied material. 19 specimens from 12 localities.

General distribution. Western Palaearctic species (Barber 2009), introduced to North America, present also in southern Sweden and south-western Finland (Andersson et al. 2008), Latvia (Bonato et al. 2005), and Lithuania (Tuf et al. 2015).

Comments. More common in western Estonia, found mainly in soil samples.

1.2. Lithobiomorpha

1.2.1. Henicopidae

***Lamyctes emarginatus* (Newport 1844)**
Fig. 2(9)

Literature sources. Riikoja 1955: 15 [as: *L. fulvicornis* Meinert], Ivask 2011: 1.

Studied material. 7 specimens from 4 localities.

General distribution. A semi-cosmopolitan species widespread also in Scandinavia and Finland (Andersson et al. 2008).

Comments. Locally common in western Estonia, not found elsewhere.

1.2.2. Lithobiidae

***Lithobius* (*Lithobius*) *borealis* Meinert, 1868**
Fig. 2(10)

Literature sources. Ivask 2011: 2.

Studied material. 11 specimens from 4 localities.

General distribution. Central and west-European species, present also in Sweden (Andersson et al. 2008), and Lithuania (Tuf et al. 2015).

Comments. More common in western Estonia, but nowhere abundant.

***Lithobius* (*Lithobius*) *erythrocephalus* C. L. Koch, 1847**
Figs 2(13), 6

Literature sources. Riikoja 1955: 15, Vilbaste 1979: 99, Vilbaste et al. 1985: 152, Ivask 2011: 2, Ivask et al. in press.

Studied material. 141 specimens from 48 localities.

General distribution. Western Palaearctic species, widespread in Scandinavia and Finland (Andersson et al. 2008), Latvia (Trautberg 1929) and Lithuania (Tuf et al. 2015).

Comments. A common species in different habitats.

***Lithobius* (*Lithobius*) *forficatus* (Linnaeus, 1758)**
Figs 2(14), 6

Literature sources. Riikoja 1955: 15, Vilbaste 1970: 173, Vilbaste et al. 1985: 152, Remm 1988: 128, Vilbaste and Vilbaste 1993: 319, Ivask 2011: 2, Kalda et al. 2015: 90, Ivask et al. in press.

Studied material. 352 specimens from 89 localities.

General distribution. Holarctic species, widespread in Scandinavia and Finland (Andersson et al. 2008), Latvia (Trautberg 1929) and Lithuania (Tuf et al. 2015), present also in Lenigrad region (north-western Russia) (Zalesskaya 1978).

Comments. One of the two most common centipede species in different habitats, but favours more xeric areas than *Lithobius curtipes*.

***Lithobius* (*Lithobius*) *lucifugus* L. Koch 1862**
Fig. 2(15)

Literature sources. Vilbaste 1979: 99, Vilbaste et al. 1985: 152, Vilbaste and Vilbaste 1993: 319.

Studied material. 5 specimens from 4 localities.

General distribution. Central- and south-east European species, present in Latvia (Trautberg 1929), Lithuania (Tuf et al. 2015) and on the Swedish islands Öland and Gotland (Andersson et al. 2008).

Comments. The species is widespread but rare in Estonia.

Lithobius (Lithobius) melanops Newport, 1845

Fig. 3(1)

Studied material. 7 specimens from 7 localities.

General distribution. Western Palaearctic species introduced to North America, present also in and Sweden (Andersson et al. 2008), Latvia (Trautberg 1929) and Lithuania (Tuf et al. 2015), synanthropic in southern Finland (Palmen 1949).

Comments. The species is widespread but infrequent in Estonia.

Lithobius (Lithobius) pelidnus Haase, 1880

Fig. 3(3)

Literature sources. Riikoja 1955: 15, Remm 1988: 128.

Studied material. 27 specimens from 4 localities.

General distribution. Central- and East-European species present also in southern Sweden (Andersson et al. 2008) and Lithuania (Tuf et al. 2015).

Comments. The species is widespread but infrequent in Estonia, found only in bogs and boreo-nemoral forests.

Lithobius (Lithobius) tenebrosus Meinert, 1872

Figs 3(4), 6

Literature sources. Riikoja, 1955: 15 [as *Lithobius nigrifrons*], Ivask 2011: 1.

Studied material. 43 specimens from 25 localities.

General distribution. Western Palaearctic species common in Finland and Sweden (Andersson et al. 2005), Latvia (Trautberg 1929) and Lithuania (Tuf et al. 2015).

Comments. A common species in different habitats, but avoids human settlements. H. Lohmander (1948) described a subspecies *fennoscandicus* Lohmander 1948 from Scandinavia, the description of which Estonian specimens generally match, but as the main subspecific difference concern colouration, more fresh specimens need to be studied.

Lithobius (Monotarsobius) crassipes C.L. Koch, 1862

Figs 2(12), 6

Literature sources. Riikoja 1955: 15, Vilbaste 1979: 99, Vilbaste et al. 1985: 152, Remm 1988: 128, Vilbaste and Vilbaste 1993: 319, Ivask et al. in press.

Studied material. 25 specimens from 18 localities.

General distribution. Palaearctic species, present also in southern Finland, Sweden (Andersson et al. 2008) and Lithuania (Tuf et al. 2015).

Comments. The species is widespread but infrequent in Estonia, avoids wet habitats.

***Lithobius* (*Monotarsobius*) *curtipes* C.L. Koch, 1847**
Figs 2(11), 6

Literature sources. Riikoja 1955: 15; Vilbaste 1970: 173; Vilbaste 1979: 99; Vilbaste et al. 1985: 152, Remm 1988: 128, Vilbaste and Vilbaste 1993: 319, Ivask 2011: 1, Kalda et al. 2015: 90, Ivask et al. in press.

Studied material. 730 specimens from 106 localities.

General distribution. Mainly a central and East European species, common in Sweden and Finland (Andersson et al. 2005, Palmén 1948), Latvia (Trautberg 1929) and Lithuania (Tuf et al. 2015).

Comments. One of the two most common centipede species in different habitats, favours more fresh habitats than *L. forficatus*.

******Lithobius* (*Sigibius*) *microps* Meinert, 1868**
Fig. 3(2)

Literature sources. Ivask et al. in press.

Studied material. 52 specimens from 17 localities.

General distribution. A western Palaearctic species, introduced to North America, also present in Finland, Sweden (Andersson et al. 2005), and Lithuania (Tuf et al. 2015).

Comments. The species is widespread but infrequent in Estonia, seems to avoid wet habitats.

2. Diplopoda
2.1. Polyxenida
2.1.1. Polyxenidae

***Polyxenus lagurus* Linnaeus, 1758**
Fig. 3(6)

Literature sources. Palmén 1949: 4, Vilbaste 1953: 16, Vilbaste 1970: 174, Remm 1988: 128, Kime and Enghoff 2011: 21.

Studied material. 27 specimens from 8 localities.

General distribution. Holarctic species, present in Latvia (Spuņģis 2010), Lithuania (Atlavinytė and Lokshina 1971), Sweden, Finland (Andersson et al. 2008) and Leningrad region (north-western Russia) (Lokshina 1969).

Comments. The species is common in soil near seashore in Western Estonia, but rare and saproxylic inland. It may be more widespread, but underdetected due to its small size.

2.2. Polyzoniida
2.2.1. Polyzoniidae

Polyzonium germanicum Brandt, 1837
Fig. 3(7)

Literature sources. Schubart 1930: 193, Vilbaste 1953: 45, Vilbaste 1970: 174, Vilbaste 1979: 99, Vilbaste et al. 1985: 152, Remm 1988: 128, Vilbaste and Vilbaste 1993: 319, Kime and Enghoff 2011: 42.

Studied material. 26 specimens from 16 localities.

General distribution. Western Palaearctic species, present in Latvia (Spuņģis 2010), Sweden, and Finland (Andersson et al. 2008).

Comments. The species is widespread but infrequent in different habitats, favours more fresh habitats and has not been found in human-disturbed areas.

2.3. Chordeumatida
2.3.1. Craspedosomatidae

**Craspedosoma raulinsii* Leach, 1814
Figs 3(8), 7

Studied material. 277 specimens from 23 localities.

General distribution. Western Palaearctic species introduced also to North America, present in Latvia (Spuņģis 2010), Lithuania (Atlavinytė and Lokshina 1971), Sweden, and Finland (Andersson et al. 2008).

Comments. This represents the first formal record of the species in Estonia after its mention by Saar and Takkis (2010) in the popular journal GEO. The species is widespread but favours fresh habitats. It seems to have recently colonised Estonia (but see Discussion).

2.3.2 Mastigophorophyllidae

Mastigophorophyllon saxonicum Verhoeff, 1916
Fig. 3(9)

Literature sources. Schubart 1930: 193, Vilbaste 1953: 18.

General distribution. Central European species absent from Scandinavia and Finland (Andersson et al. 2008, 2013), present in Lithuania (Atlavinytė and Lokshina 1971) formerly found from Latvia, but not recently recorded (Spuņģis 2010).

Comments. The species was described as frequent in southern Estonia (Schubart 1930) but there are no recent records since Vilbaste 1953. The species may have become more rare or extinct in Estonia. Schubart (1930) mentioned a few exact localities in his

work, viz. Sõrve peninsula, Abruka Island, the vicinity of Pärnu and Vilbaste (1953) repeats these data and adds Tartu as the northern boundary of its range. All these localities were studied in the current research but the species was not found. It is possible that the record from Tartu refers instead to Haase's specimen of *Craspedosoma mutabile* var. *fasciatum*, interpreted as a misidentification of *M. saxonicum* by Schubart (1930). Vilbaste does not mention the species (nor any other Chordeumatids) in any of his later works.

2.4. Polydesmida
2.4.1. Polydesmidae

***Brachydesmus superus* Latzel, 1884**
Fig. 3(11)

Literature sources. Schubart 1930: 193, Vilbaste 1953: 19, Vilbaste 1970: 174, Ivask et al. in press.

Studied material. 14 specimens from 8 localities.

General distribution. Western Palaearctic species, introduced also to many other parts of the world, present in Latvia (Spuņģis 2010), Lithuania (Atlavinytė and Lokshina 1971), Sweden, and Finland (Andersson et al. 2008).

Comments. The species is widespread, but infrequent, in different habitats.

***Polydesmus complanatus* (Linnaeus, 1761)**
Figs 3(12), 7

Literature sources. Schubart 1930: 193, Vilbaste 1953: 20, Vilbaste et al. 1985: 152, Remm 1988: 128, Kime and Enghoff 2011: 62.

Studied material. 59 specimens from 24 localities.

General distribution. Western Palaearctic species, introduced also to North America, present in Latvia (Spuņģis 2010), Lithuania (Atlavinytė and Lokshina 1971), Sweden, Finland (Andersson et al. 2008), and Leningrad region (north-western Russia) (Lokshina 1969).

Comments. The species is widespread and common, in different habitats.

***Polydesmus denticulatus* C.L. Koch, 1847**
Figs 3(13), 7

Literature sources. Schubart 1930: 193, Vilbaste 1953: 21, Vilbaste 1970: 174, Vilbaste 1979: 99, Vilbaste et al. 1985: 152, Kime and Enghoff 2011: 63, Kalda et al. 2015: 90, Ivask et al. in press.

Studied material. 796 specimens from 82 localities.

General distribution. Western Palaearctic species, introduced also to North America, common in Latvia (Spuņģis 2010), Lithuania (Atlavinytė and Lokshina

1971), Sweden, Finland (Andersson et al. 2008), Leningrad, and Pskov regions (northwestern Russia) (Lokshina 1969).

Comments. The species is widespread and common, in different habitats.

***Polydesmus inconstans* Latzel, 1884**
Figs 3(14), 7

Literature sources. Schubart 1930: 193 [as *Polydesmus coriaceus*], Vilbaste 1953: 22, Vilbaste 1970: 174, Remm 1988: 128, Kime and Enghoff 2011: 65, Ivask et al. in press.

Studied material. 29 specimens from 13 localities.

General distribution. Western Palaearctic species, introduced also to North America, present in Latvia (Spuņģis 2010), Lithuania (Atlavinytė and Lokshina 1971), Sweden, and Finland (Andersson et al. 2008).

Comments. The species is widespread but infrequent, in different habitats, but prefers woodlands. There has been a confusion of this species with Western European *P. coriaceus* Porat, 1871 (cf. Vilbaste 1953, Blower 1985, Spuņģis 2010). The record of *P. coriaceus* in a posthumously published work by J. Vilbaste (Vilbaste and Vilbaste 1993) is inexplicable and obviously erroneous. The Estonian specimens identified as *P. coriaceus* in Zoologische Staatssammlung München, Germany (Verhoeff collection, collected from Tallinn, no date) also belong to *P. inconstans* (J. Spelda, pers. comm.).

2.5. Julida
2.5.1. Blaniulidae

***Blaniulus guttulatus* (Fabricius, 1798)**
Fig. 3(15)

Literature sources. Schubart 1930: 193, Kaarep et al. 1949: 176, Vilbaste 1953: 29, Kime and Enghoff 2017: 27, Ivask et al. in press.

Studied material. 35 specimens from 6 localities.

General distribution. Western Palaearctic species, introduced also to many other parts of the world, present in Latvia (Spuņģis 2010), Lithuania (Atlavinytė and Lokshina 1971), Sweden, Finland (Andersson et al. 2008) and Leningrad region (northwestern Russia) (Lokshina 1969).

Comments. The species is widespread but infrequent, mostly synanthropic.

***Boreoiulus tenuis* (Bigler, 1913)**
Fig. 4(1)

Literature sources. Vilbaste 1953: 29, Ivask et al. in press.

Studied material. 7 specimens from 4 localities.

General distribution. Northern and central European species, present in Latvia (Spuņģis 2010), Finland (Andersson et al. 2008), and Leningrad region (north-western Russia) (Lokshina 1969).

Comments. The species is widespread but rare.

***Nopoiulus kochii* (Gervais, 1847)**
Fig. 4(2)

Literature sources. Schubart 1930: 193 [as *Nopoiulus armatus*], Vilbaste 1953: 26, Vilbaste 1970: 174 [as *Nopoiulus venustus*], Kime and Enghoff 2017: 33.

Studied material. 7 specimens from 3 localities.

General distribution. Western Palaearctic species, introduced also to many other parts of the world, present in Latvia (Spuņģis 2010), Lithuania (Atlavinytė and Lokshina 1971), Sweden, Finland (Andersson et al. 2008), and Leningrad region (northwWestern Russia) (Lokshina 1969).

Comments. The species is rare, found only in northern and western Estonia.

***Proteroiulus fuscus* (Am Stein, 1857)**
Figs 4(3), 7

Literature sources. Schubart 1924: 57 [as *Nopoiulus palmatus caelebs*], Schubart 1930: 193, Vilbaste 1953: 27, Vilbaste 1970: 174, Vilbaste et al. 1985: 152, Remm 1988: 128, Vilbaste and Vilbaste 1993: 319, Kime and Enghoff 2017: 34, Ivask et al. in press.

Studied material. 239 specimens from 42 localities.

General distribution. Western Palaearctic species, introduced also to North America, present in Latvia (Spuņģis 2010), Lithuania (Atlavinytė and Lokshina 1971), Sweden, Finland (Andersson et al. 2008), Leningrad, and Novgorod regions (north-western Russia) (Lokshina 1969).

Comments. The species is widespread and common, especially in moist habitats, usually associated with decaying wood.

2.5.2. Nemasomatidae

***Nemasoma varicorne* C. L. Koch, 1847**
Figs 3(10), 7

Literature sources. Vilbaste 1953: 25 [as *Isobates varicornis*], Kime and Enghoff 2017: 199, Ivask et al. in press.

Studied material. 126 specimens from 28 localities.

General distribution. Central and East-European species, present in Latvia (Spuņģis 2010), Lithuania (Atlavinytė and Lokshina 1971), Sweden and Finland (Andersson et al. 2008).

Comments. The species is widespread and common in different types of woodland. Climbs also in trees (as several individuals were found in trunk window traps).

2.5.3. Julidae

***Allajulus nitidus* (Verhoeff, 1891)**
Fig. 4(4)

Literature sources. Ivask 2011: 1, Ivask et al. in press.

Studied material. 38 specimens from 14 localities.

General distribution. Central and northern European species, not found in Latvia (Spuņģis 2010) and Finland, present in Sweden (Andersson et al. 2008, 2013).

Comments. The species is widespread but frequent only in western Estonia, mostly associated with open landscape.

***Brachyiulus pusillus* (Leach, 1814)**
Fig. 4(5)

Literature sources. Schubart 1930: 193 [as *Brachyiulus littoralis*], Vilbaste 1953: 42 [as *Brachyiulus littoralis*], Kime and Enghoff 2017: 47.

General distribution. Western Palaearctic species introduced to many parts of the world, rare in Latvia (Spuņģis 2010), present in Lithuania (Atlavinytė and Lokshina 1971) and southern Sweden, not found in Finland (Andersson et al. 2008, 2013).

Comments. No specimens were collected during our studies or are preserved in Estonian collections. The current status of the species in Estonia is unclear as it has been reported as rare also in the past. It seems that both Schubart (1930) and Vilbaste (1953) refer to the same single specimen (loc. 20). There appears to be another finding from Hiiumaa Island according to Kime and Enghoff (2017), but we failed to trace the origin of that record (H. Enghoff, pers. comm.). It is not impossible that the record from Hiiumaa is a misinterpretation of the historical place name Tickhof, which is present also on Hiiumaa (Kongo 2016), but Schubart states the locality as "*in einem Garten in Tickhof auf Ösel*" - "in a garden in Tickhof on Ösel (=Saaremaa island)", and Vilbaste (1953) repeats that almost literally.

******Cylindroiulus britannicus* (Verhoeff, 1891)**
Fig. 4(6)

Studied material. 10 specimens from 2 localities.

General distribution. Western Palaearctic species, introduced to many parts of the world, present in Latvia (Spuņģis 2010), Lithuania (Atlavinytė and Lokshina 1971), Sweden and Finland (Andersson et al. 2008).

Comments. The species is rare, found only on western Estonian islands.

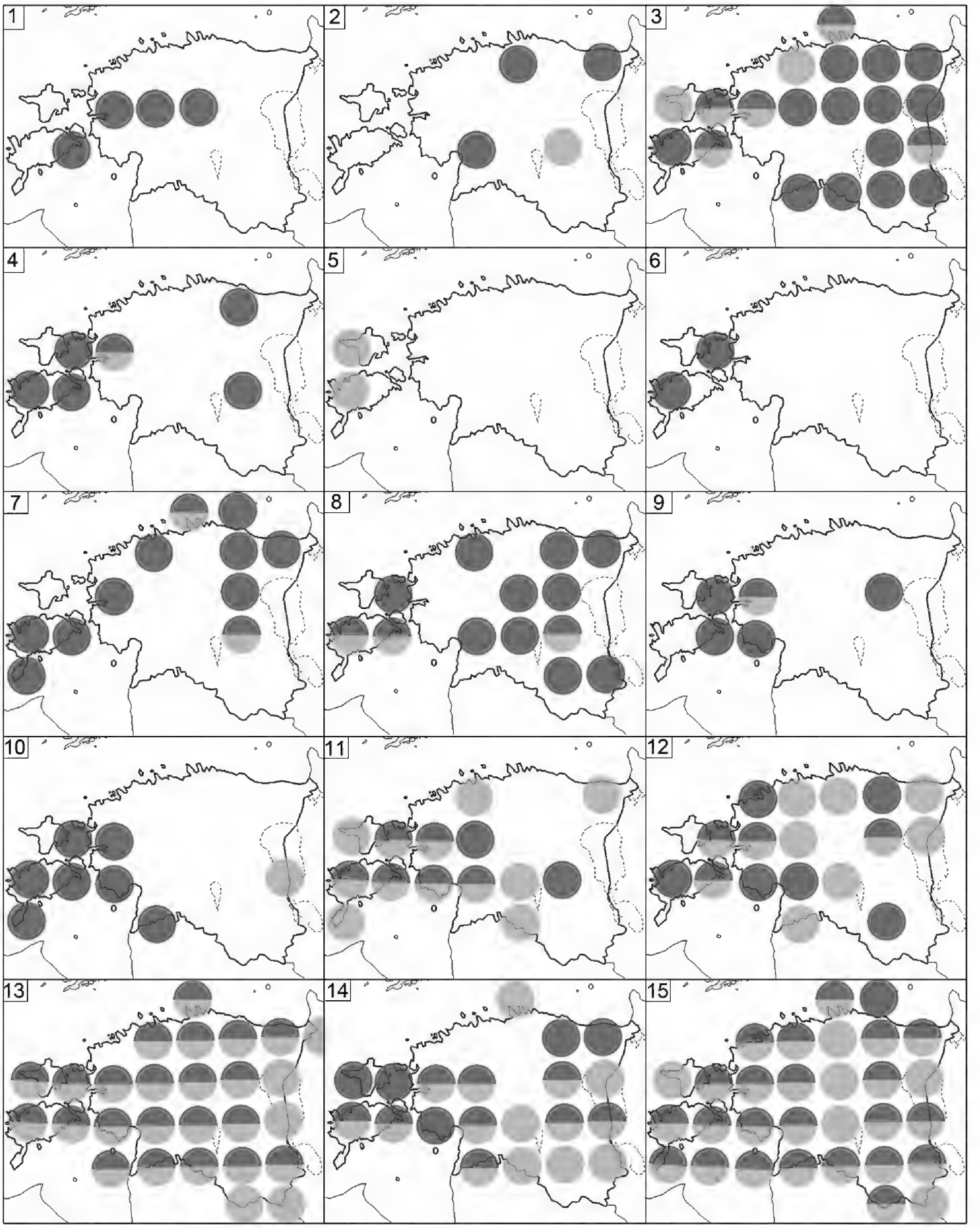

Figure 4. Distribution of Estonian Diplopoda. **1** *Boreoiulus tenuis* **2** *Nopoiulus kochii* **3** *Proteroiulus fuscus* **4** *Allajulus nitidus* **5** *Brachyiulus pusillus* **6** *Cylindroiulus britannicus* **7** *C. latestriatus* **8** *C. caeruleocinctus* **9** *Julus scandinavius* **10** *J. scanicus* **11** *J. terrestris* **12** *Leptoiulus cibdellus* **13** *L. proximus* **14** *Megaphyllum sjaelandicum* **15** *Ommatoiulus sabulosus*. For symbols see Fig. 2.

Cylindroiulus caeruleocinctus (Wood, 1864)

Figs 4(8), 7

Literature sources. Schubart 1930: 193 [as *Cylindroiulus teutonicus*], Kaarep et al. 1949: 176 [as *Cylindroiulus teutonicus*], Vilbaste 1953: 33 [as *Cylindroiulus teutonicus*], Kime and Enghoff 2017: 55.

Studied material. 237 specimens from 31 localities.

General distribution. Western Palaearctic species, introduced to North America, present in Latvia (Spuņģis 2010), Lithuania (Atlavinytė and Lokshina 1971), Sweden, Finland (Andersson et al. 2008), Leningrad, and Pskov regions (north-western Russia) (Lokshina 1969).

Comments. The species is widespread and common, especially in or close to human settlements. The records of *Ophyiulus pilosus* (Newport, 1842) as a pest of potatoes in Estonia (Zolk 1923) probably refer to this species instead (Vilbaste 1953).

Cylindroiulus latestriatus (Curtis, 1845)

Fig. 4(7)

Literature sources. Schubart 1930: 193 [as *Cylindroiulus frisius*], Vilbaste 1953: 35 [as *Cylindroiulus frisius*], Kime and Enghoff 2017: 63.

Studied material. 44 specimens from 14 localities.

General distribution. Western Palaearctic species, introduced to many parts of the world, present in Latvia (Spuņģis 2010), Lithuania (Atlavinytė and Lokshina 1971), Sweden, Finland (Andersson et al. 2008), and Leningrad region (north-western Russia) (Lokshina 1969).

Comments. The species is widespread but infrequent, more common in western Estonia. It seems to prefer drier habitats.

Julus scandinavius Latzel, 1884

Fig. 4(9)

Literature sources. Ivask 2011: 2, Ivask et al. in press.

Studied material. 17 specimens from 7 localities.

General distribution. Central and northern European species, not found in Latvia (Spuņģis 2010) and in Finland, present in southern Sweden (Andersson et al. 2008).

Comments. The species is widespread but infrequent, most findings are from Western Estonia.

Julus scanicus Lohmander, 1925

Figs 4(10), 7

Literature sources. Kaarep et al. 1949: 176, Vilbaste 1953: 38, Ivask 2011: 2, Ivask et al. in press.

Studied material. 252 specimens from 22 localities.

General distribution. Mainly a Central European species, present in Latvia (Spuņģis 2010), and southern Sweden, not found in Finland (Andersson et al. 2008, 2013).

Comments. The species is common in western Estonia, but not found elsewhere.

***Julus terrestris* Linnaeus, 1758**
Figs 4(11), 7

Literature sources. Schubart 1930: 193, Vilbaste 1953: 39, Vilbaste 1970: 174, Vilbaste et al. 1985: 152, Kime and Enghoff 2017: 96, Ivask et al. in press.

Studied material. 304 specimens from 34 localities.

General distribution. Mainly a central European species, present in Latvia (Spuņģis 2010), Lithuania (Atlavinytė and Lokshina 1971), Sweden, and Finland (Andersson et al. 2008).

Comments. The species is frequent in western Estonia, but rare elsewhere. Clearly prefers open landscapes.

***Leptoiulus cibdellus* (Chamberlin 1921)**
Figs 4(12), 7

Literature sources. Schubart 1930: 193 [as *Leptoiulus minutus*], Vilbaste 1953: 40 [as *Leptoiulus minutus*], Ivask 2011: 1, Kime and Enghoff 2017: 101, Ivask et al. in press.

Studied material. 274 specimens from 30 localities.

General distribution. Central European species, present in Latvia (Spuņģis 2010), Lithuania (Atlavinytė and Lokshina 1971), Sweden, and Finland (Andersson et al. 2008).

Comments. The species is widespread, but common only in western Estonia. Clearly prefers open landscapes.

***Leptoiulus proximus* (Němec, 1896)**
Figs 4(13), 8

Literature sources. Schubart 1924: 57 [as *Leptoiulus buckkensis*], Schubart 1930: 193 [as *Leptoiulus buekkensis*], Vilbaste 1953: 39, Vilbaste 1970: 174, Vilbaste 1979: 99, Vilbaste et al. 1985: 152, Remm 1988: 128, Kime and Enghoff 2017: 250, Ivask et al. in press.

Studied material. 584 specimens from 81 localities.

General distribution. present in Latvia (Spuņģis 2010), Lithuania (Atlavinytė and Lokshina 1971), Sweden, Finland (Andersson et al. 2008), and Leningrad region (north-western Russia) (Lokshina 1969).

Comments. The species is widespread and very common in different habitats, with a slight preference to open landscape. The report of *Ophyiulus pilosus* in Estonia (Ivask 2011) has proved erroneous after re-examining the material, and belongs also to this species.

***Megaphyllum sjaelandicum* (Meinert, 1868)**
Figs 4(14), 8

Literature sources. Schubart 1930: 193 [as *Chromatoiulus sjaelandicus*], Vilbaste 1953: 43 [as *Chromatoiulus sjaelandicus*], Vilbaste et al. 1985: 152, Remm 1988: 128, Lazányi and Vagalinski 2013: 86, Kime and Enghoff 2017: 128.

Studied material. 80 specimens from 25 localities.

General distribution. Central and eastern Palaearctic species, present in Latvia (Spuņģis 2010), southern Sweden, Finland (Andersson et al. 2008), Leningrad and Novgorod regions (north-western Russia) (Lokshina 1969).

Comments. The species is widespread and common in different habitats, with a slight preference to fresh forests.

***Ommatoiulus sabulosus* (Linnaeus, 1758)**
Figs 4(15), 8

Literature sources. Schubart 1930: 193 [as *Archiulus sabulosus*], Vilbaste 1953: 45 [as *Schizophyllum sabulosum*], Vilbaste 1979: 99 [as *Schizophyllum sabulosum*], Remm 1988: 128 [as *Schizophyllum sabulosum*], Kalda et al. 2015: 90, Kime and Enghoff 2017: 276, Ivask et al. in press.

Studied material. 659 specimens from 84 localities.

General distribution. Western Palaearctic species, common in Latvia (Spuņģis 2010), Sweden, Finland (Andersson et al. 2008)m and Leningrad region (north-western Russia) (Lokshina 1969).

Comments. A very common species in different habitats. Climbs also in trees (as several individuals were found in trunk window traps). A mass outbreak of the species was observed near Ikla (south-western Estonia) in June 2018, where numerous specimens entered houses (see also Discussion).

***Rossiulus vilnensis* (Jawlowski, 1925)**
Fig. 5(1)

Literature sources. Schubart 1930: 193 [as *Archiulus vilnense*], Vilbaste 1953: 44 [as *Schizophyllum (Sarmatiulus) vilnense*], Vilbaste and Vilbaste 1993: 319, Kime and Enghoff 2017: 155.

Studied material. 16 specimens from 8 localities.

General distribution. Central and east-European species (Lokshina 1969), present in Lithuania (Atlavinytė and Lokshina 1971) rare in Latvia (Spuņģis 2010), not found in Finland and Sweden (Andersson et al. 2008, 2013).

Comments. The species is widespread but infrequent, not found from northern Estonia.

***Unciger foetidus* C.L. Koch, 1838**
Figs 5(2), 8

Literature sources. Schubart 1930: 193, Vilbaste 1953: 41, Vilbaste 1979: 99, Kime and Enghoff 2017: 168.

Studied material. 728 specimens from 18 localities.

General distribution. Western Palaearctic species, present in Latvia (Spuņģis 2010), Lithuania (Atlavinytė and Lokshina 1971), Sweden, southern Finland (Andersson et al. 2008).

Comments. The species is widespread and common, in different habitats, but avoids very wet ones and seems to be favoured by human influence.

***Xestoiulus laeticollis* (Porat, 1889)**
Fig. 5(3)

Literature sources. Schubart 1930: 193 [as *Microiulus laeticollis mierzejewskii*], Vilbaste et al. 1985: 38 [as *Microiulus laeticollis mierzejewskii*], Remm 1988: 128, Vilbaste and Vilbaste 1993: 319, Kime and Enghoff 2017: 171, Ivask et al. in press.

Studied material. 19 specimens from 13 localities.

General distribution. Central and east European species, present in Lithuania (Atlavinytė and Lokshina 1971), Latvia (Spuņģis 2010) and southern Sweden, not found in Finland (Andersson et al. 2008, 2013).

Comments. The species is infrequent and found only from Western Estonia.

3. Symphyla

3.1 Scutigerellidae

****Scutigerella immaculata* (Newport, 1845)**
Fig. 5(4)

Studied material. 14 specimens from 7 localities.

General distribution. Unclear, present in Finland and Sweden (Andersson et al. 2005, 2008, 2013) probably also in Latvia (Eglītis 1954).

3.2 Scolopendrellidae

****Symphylella vulgaris* (Hansen, 1903)**
Fig. 5(5)

Studied material. 10 specimens from 6 localities.

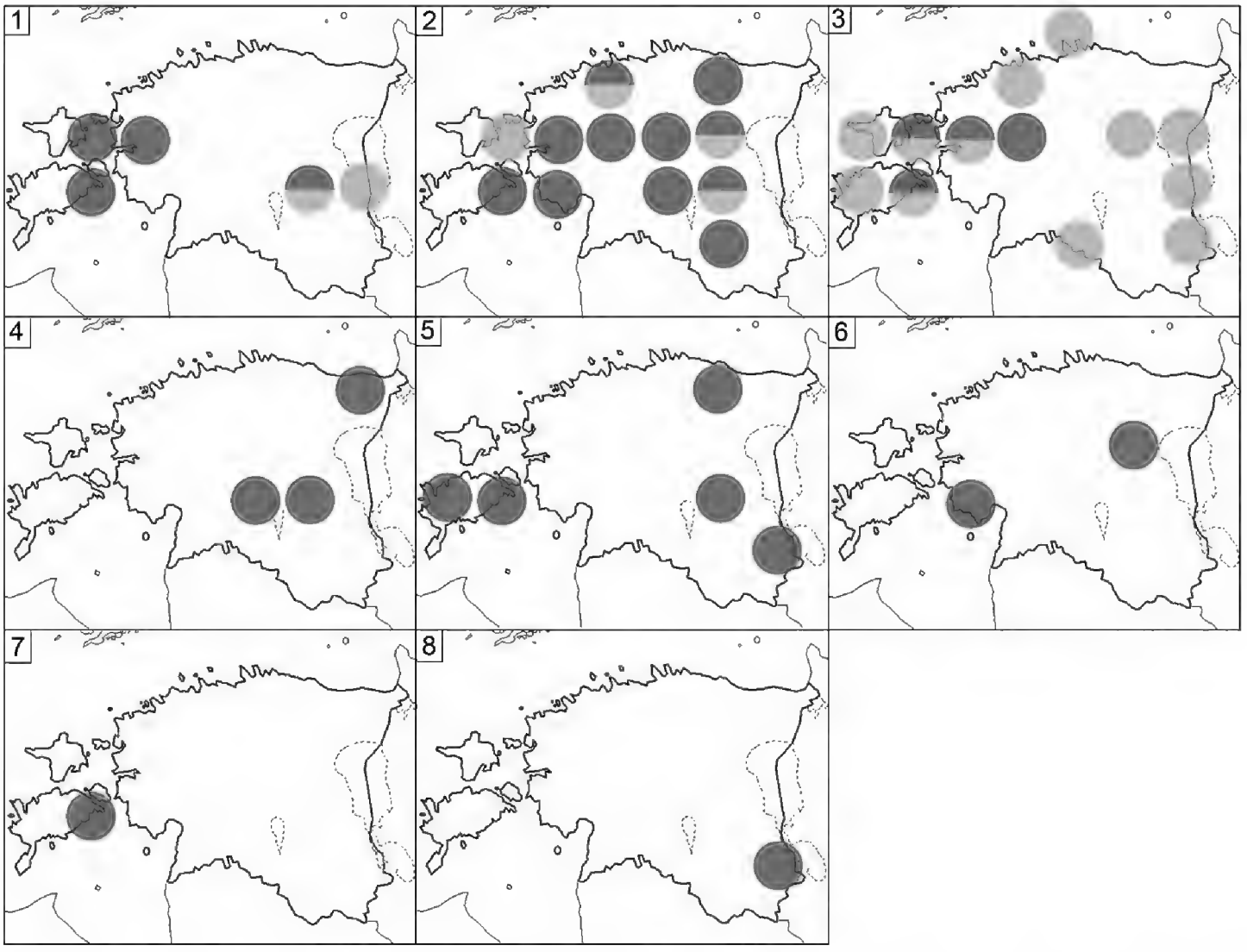

Figure 5. Distribution of Estonian Diplopoda (**1–3**), Symphyla (**4–6**) and Pauropoda (**7–8**). **1** *Rossiulus vilnensis* **2** *Unciger foetidus* **3** *Xestoiulus laeticollis* **4** *Scutigerella immaculata* **5** *Symphylella vulgaris* **6** *Scolopendrellopsis subnuda* **7** *Decapauropus cuenoti* **8** *D. gracilis*. For symbols see Fig. 2.

General distribution. A widespread Holarctic species, present in Finland and Sweden (Andersson et al. 2008), possibly also in Latvia (*Symphylella* sp. in Eglītis 1954).

****Scolopendrellopsis subnuda*** **(Hansen, 1903)**
Fig. 5(6)
Studied material. 5 specimens from 2 localities.

General distribution. Western Palaearctic species, present also in Sweden and Finland (Andersson et al. 2005).

4. Pauropoda

We regard the record of *Pauropus huxleyi* Lubbock, 1867 near Narva (Schmidt 1894, Andersson et al. 2005: 274) being dubious, as it is unclear from which side of the current Estonian-Russian border it was collected and since several related species were undescribed at the time.

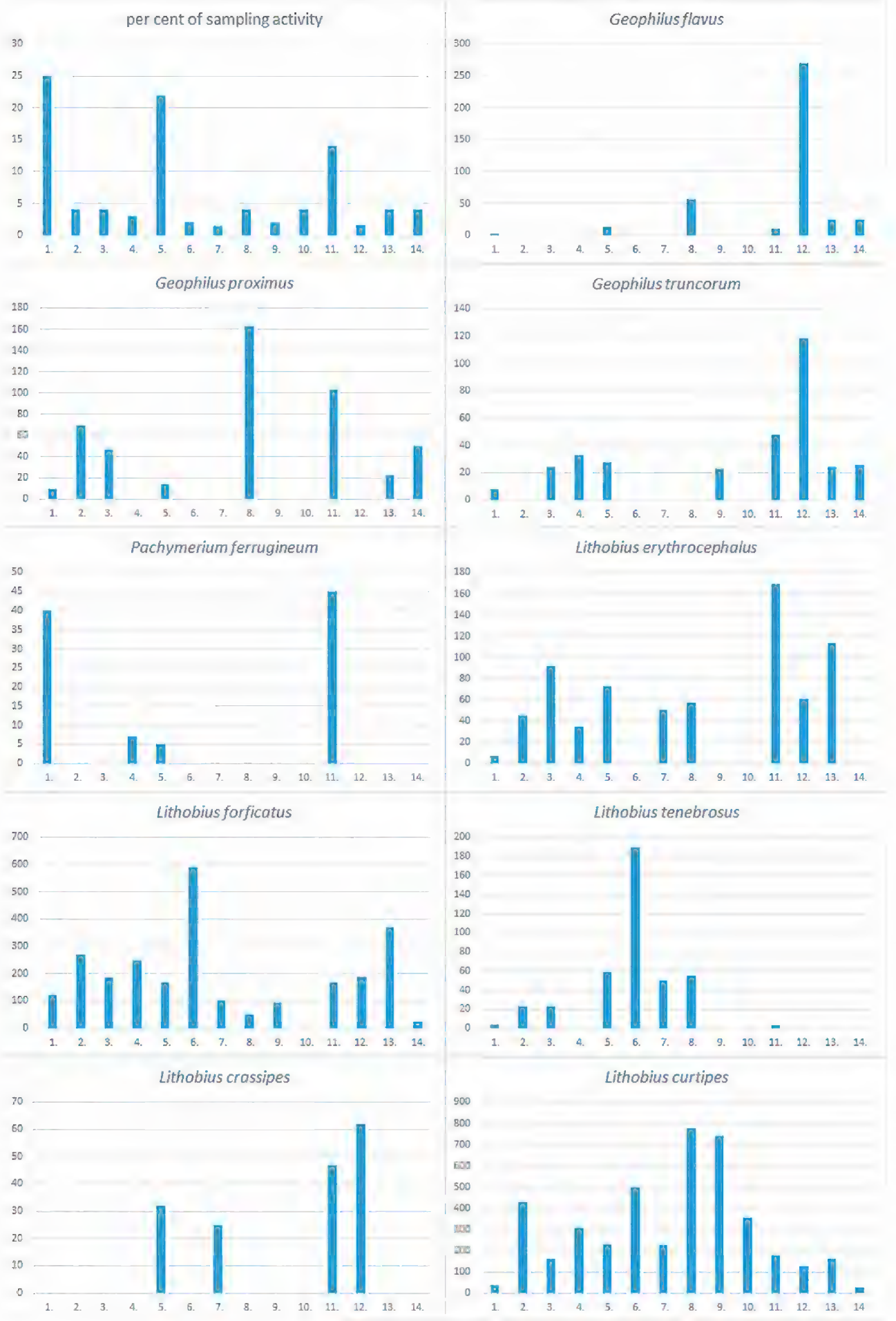

Figure 6. Proportion of samples from different habitats and habitat preferences of common Estonian Chilopoda. Vertical axis: relative abundances (numbers of findings divided by proportion of sampling effort). Horizontal axis numbers represent habitat types as follows: **1** Coastal meadows and alvars **2** Broad-leaved (nemoral) forests **3** Boreo-nemoral deciduous forests **4** Dry heathland forests **5** Drier boreo-nemoral mixed forests **6** Mesophilic boreal forests **7** Hillock forests **8** Carrs and swamp forests **9** Bogs **10** Fens and waterlogged meadows **11** Inland mesophilic grasslands **12** Rural gardens **13** Urban parks and graveyards **14** Arable fields. For detailed description of habitats see Material and methods.

Figure 7. Habitat preferences of common Estonian Diplopoda. For explanation of the vertical axis and numbers denoting different habitats on the horizontal axis see Fig. 6.

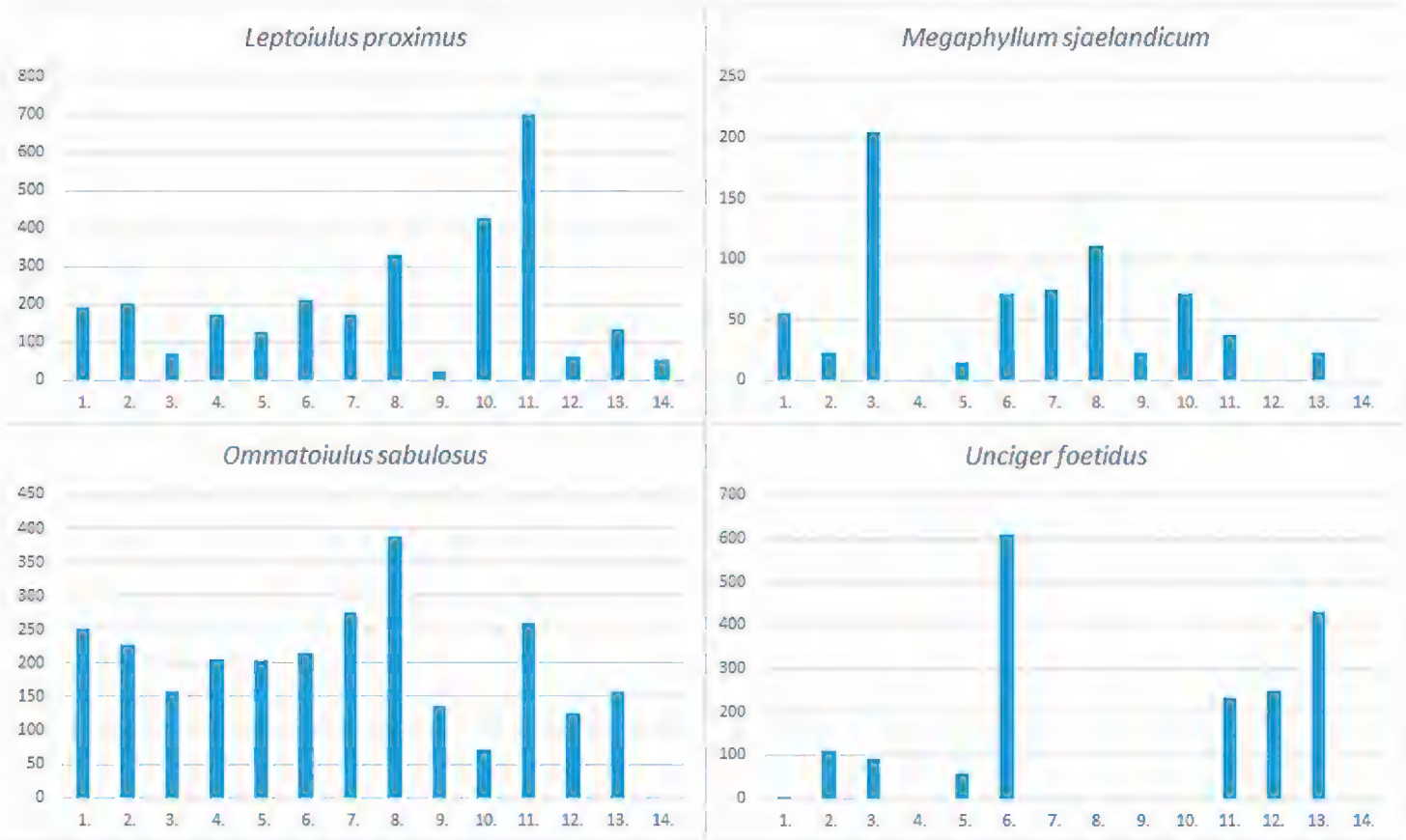

Figure 8. Habitat preferences of common Estonian Diplopoda. For explanation of the vertical axis and numbers denoting different habitats on the horizontal axis see Fig. 6.

4.1. Pauropodidae

****Decapauropus cuenoti* (Remy, 1931)**
Fig. 5(7)

Studied material. 5 specimens from 1 locality.

General distribution. Possibly a Holarctic species with predominantly a northern distribution, present also in Sweden and Finland (Andersson et al. 2005).

****Decapauropus gracilis* (Hansen, 1902)**
Fig. 5(8)

Studied material. 1 specimen from 1 locality.

General distribution. Possibly a Holarctic species with introductions to South Asia and South America, present also in Sweden and Finland (Andersson et al. 2005).

Discussion

The current study adds six centipede and two millipede new country records, while two millipedes, viz. *Polydesmus coriaceus* and *Ophyiulus pilosus* are presently removed from the Estonian checklist. All the Symphylan and Pauropod species represent new records.

It is unclear whether the new records are due to insufficient previous data (which may well be true for centipedes, except *Stenotaenia linearis*) or range shifts. The human or climate driven range shifts up to over hundred km northwards in recent decades have been also detected elsewhere (David 2009). The changes in occurrence frequencies of the species that have been observed also in the neighbouring countries, e.g., in Finland by Lehtinen and Terhivuo (1996), concern *Cylindroiulus caeruleocinctus* and *Unciger foetidus*. Both species were earlier reported as rare in Estonia (cf. Vilbaste 1953) but proved to be common and widespread after the present study. Mass outbreaks of some julid species have also spread northwards (Kania and Tracz 2005) and were recently seen in Lithuania e.g., *O. sabulosus* in 2015–2016 (J. Rimšaitė pers. comm.). This type of event is reported here for the first time in Estonia, with a localised outbreak of *O. sabulosus* in south-western Estonia, occurred in June 2018. The Estonian findings of *Lithobius pelidnus*, *Strigamia transsilvanica*, *Brachyiulus pusillus*, *Allajulus nitidus*, *Xestoiulus laeticollis*, and *Rossiulus vilnense* represent the northernmost records for those species.

The range of *Craspedosoma raulinsii* seems to expand north and eastwards. It was apparently first collected in Latvia between 2003 and 2008 (Andersson et al. 2005, Spuņģis 2010), 2010 in Estonia and 2006 in Moscow region of Russia (Golovatch and Matyukhin 2011). The first record(s) from Finland seem to be probably from 2001 to 2005 (reported as present in southern Finland by Andersson et al. 2005, but absent according to Kime 2001). However, we failed to find the original source of the Finnish records (V. Huhta, H. Enghoff, P. Djursvoll, P. Cardoso pers. comm.). The actual appearance of *C. raulinsii* in the Northern Baltic region can be decades earlier, as the myriapod fauna of Estonia and Latvia was not systematically monitored in the 1980-s and 1990-s. On the other hand, if the record of *Craspedosoma mutabile* var. *fasciatum* (if a synonym of *C. raulinsii*, as in Sierwald and Spelda 2018) from Tartu (Haase 1886) is correct, the species distribution range may have fluctuated also in the past. The name is a synonym of *Mastigona bosniense* according to Schubart (1934), and the identity with that species is also possible, as a specimen of *Mastigona* sp. (as *Heteroporatia* sp.) has been found in Latvia (Becker 1929, Spuņģis 2010).

Four species, viz. *Strongylosoma stigmatosum*, *Cylindroiulus punctatus*, *Archiboreiulus pallidus* and *Choneiulus palmatus*, occurring in neighbouring Latvia and/or Finland might be found also in Estonia, but more studies, especially in southern Estonia are needed. The species *Mastigophorophyllon saxonicum*, previously reported from many localities in southern Estonia was not re-found, and appears to have become more rare or extinct (which is also the case in Latvia, Spuņģis 2010). Spuņģis (2010) discusses the possibility that the northern Baltic records of *M. saxonicum* are misidentifications of *C. raulinsii*, which seems improbable to us as both species should have been well known for O. Schubart. Several species e.g., *Lamyctes emarginatus*, *Pachymerium ferrugineum*, *Julus terrestris*, *Julus scandinavius*, *Allajulus nitidus*, *Leptoiulus cibdellus*, and *Xestoiulus laeticollis* are more common in western Estonia or even restricted to this region characterised by milder maritime climate and calcareous soils e.g., *Geophilus carpophagus*, *Boreoiulus tenuis*, *Julus scanicus*, and *Cylindroiulus britannicus*.

The currently known fauna of Estonian Diplopoda and Chilopoda is quite similar to the neighbouring regions. 79% of the species are shared with Finland and 87.5 % are shared with Latvia. The similarity to Latvian fauna may be in fact even higher, as several species occurring both in Estonia and Lithuania might be present also in Latvia. Estonian Symphyla and Pauropoda deserve further attention. At present, they remain too poorly known to allow for any comparisons.

Acknowledgements

The study was partially funded by institutional research funding (IUT21-1) of the Estonian Ministry of Education and Research. We would like to thank Per Djursvoll, Henrik Enghoff, Lucio Bonato, Pedro Cardoso, Jolanta Rimšaitė and Jörg Spelda for various information. Our gratitude is also due to Mart Meriste, Ilmar Süda, Tõnu Talvi, Allan Selin, Urmas Jürivete, Tõnu Kesküla, Märt Kruus, Heli Kirik, Siiri Jürgenstein, Mati Martin, Erki Õunap, Jaan Viidalepp, Miina Oras and Hannes Järve who collected myriapods for the present study. Peter Decker and Ivan H. Tuf are thanked for their helpful comments and suggestions to the manuscript.

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Supplementary material 1

Published records of Estonian myriapods

Authors: Kaarel Sammet, Mari Ivask, Olavi Kurina

Data type: occurrence

Explanation note: Full collecting details for one finding from each locality. The locality numbers correspond to those in Table 1 and Figure 1.

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